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By R. C. TREHERNE

Chief, Division of Field Crop and Garden Insects



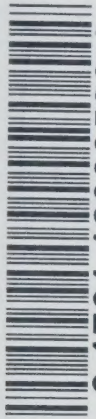
FEMALE OF THE CABBAGE ROOT MAGGOT FLY
ENLARGED ABOUT THREE TIMES


(After Gibson and Treherne from photograph by J. T. Wadsworth.)

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ROOT MAGGOTS AND THEIR CONTROL*

By R. C. Treherne, Chief, Division of Field Crop and Garden Insects.

The annual loss to field and vegetable crops in Canada by root maggots amounts to many thousands of dollars. Three species are responsible for this loss, viz., the Cabbage Maggot, *Hylemyia brassicae* Bouché, which attacks plants of the cruciferae or mustard family such as cabbage, cauliflower, radish, turnip and rape, and, on occasion, such plants as celery, beets and beans; the Onion Maggot, *Hylemyia antiqua* Meig., which attacks under ordinary conditions the onion plant alone; and the Seed-corn Maggot, *Hylemyia cilicrura* Rond., which attacks a wide range of crops such as beans, peas, corn and those cruciferous crops favoured by the Cabbage Maggot. A fourth species, viz., the Seed Potato Maggot, *Hylemyia trichodactyla* Rond., which attacks in particular seed potatoes and such crops as turnips, cucumbers, beans and asparagus, has recently been found in Eastern Canada, but its injuries as yet are unimportant. These four insects are distinct species though closely related; they all have similar habits in connection with the plants they attack.

In general, the adults are all small flies, somewhat resembling the common house fly, but smaller and more slender. They may be seen flying in the early spring, close to the ground, depositing small, white, elongate eggs, on the stems of the plants or in the surrounding soil. These eggs hatch in a few days (3-8 days) into small white, footless maggots, which at once burrow down into the soil, enter the roots or bulbs and destroy them. In two to three weeks these maggots become full grown. They then usually leave the plant and pupate in the soil close by. The puparium is dark reddish-brown in colour, approximately one-quarter of an inch in length and somewhat resembling a grain of wheat in appearance. In the summer months they remain in this condition for about two weeks before the adult flies appear. Two, three and sometimes four generations occur during the course of the year, but, invariably, so far as our experience goes, the winter is passed as a puparium, from one inch to six inches deep in the soil.

CONTROL MEASURES

THE CABBAGE MAGGOT

The Corrosive Sublimate Treatment.

The corrosive sublimate (mercury bichloride) treatment is now regarded as the most economical and efficient method of controlling the Cabbage Maggot. Radishes, garden and field turnips, cabbages and cauliflowers may all be treated with this substance without fear of injury. The use of corrosive sublimate against this insect not only renders 80 per cent to 100 per cent of the plants free from attack but it also apparently has a marked beneficial effect on their growth. At least two treatments in the spring or early summer are necessary, but three are advisable in the majority of cases. Corrosive sublimate is used at the rate of one ounce to ten gallons of water. It is applied liberally to the stem and roots of each plant at weekly intervals from the fourth day after egg-laying has commenced. It is difficult to decide the date of oviposition without experience although the small white eggs may be readily seen when once

* Revision of Crop Protection Leaflet No. 4, 1918.

recognized. On the Pacific coast of British Columbia eggs may be laid as early as the first week of April. In the majority of sections in Canada, however, few eggs are laid before the middle of May in a normal season.

In seed beds of cabbages and cauliflowers, or for radishes and garden turnips, the first treatment should be made when eggs are first seen or, strictly speaking, on the third or fourth day after egg-laying has commenced. A second treatment should be given a week later. An ordinary watering can with the "rose" removed and with the aperture of the spout reduced to a convenient form, has been found to be a most practical method of application. A third treatment is not necessary.

With transplanted cabbages and cauliflowers the first treatment should be made on the fourth day after transplanting, with a second and third application following at weekly intervals. It frequently happens in a backward season that egg-laying does not commence until the time arranged for the second treat-



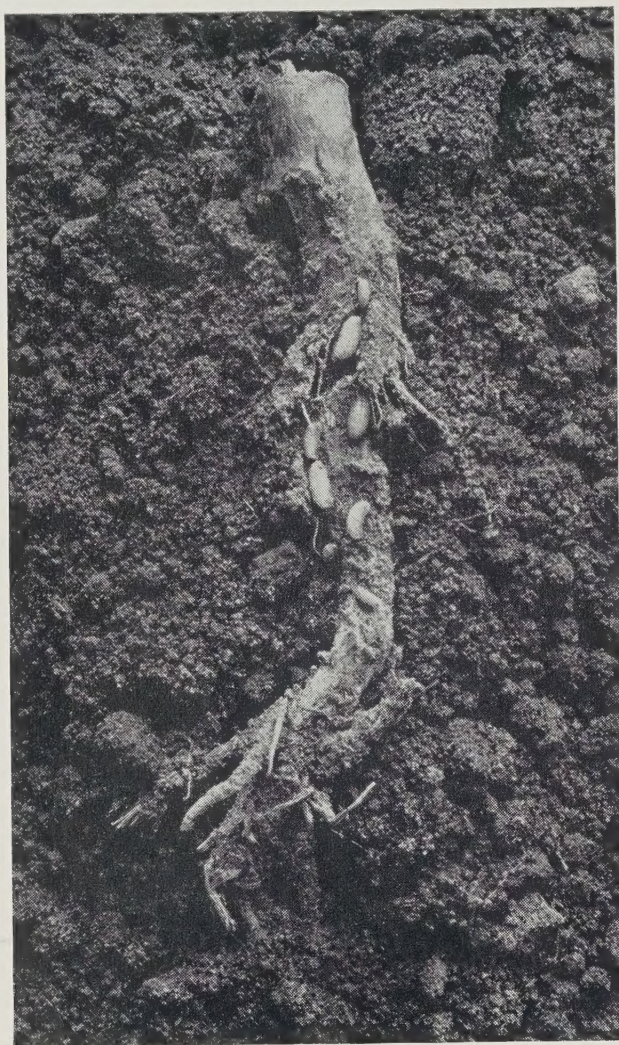
Eggs of Cabbage Root Maggot at base of stem of Cabbage Plant; slightly enlarged.
(After Gibson and Treherne.)

ment, in which case the first treatment could have been eliminated had this fact been known. The cost, however, is small and three treatments are recommended. In a small garden the applications may be made with a watering can, the liquid being directed at the stems. In medium sized plantations of from one to four acres, the applications may be economically applied by means of wooden buckets and "dippers". A yoke carrying two four-gallon tin cans containing the diluted mixture has proved a satisfactory method of making the applications, the liquid being dipped out by means of a small can attached to a wooden handle. A central supply of the concentrated mixture of corrosive sublimate with water should be available in the centre of the plantation.

In even larger plantations barrels containing the diluted mixture may be carried on wagons. Leads of rubber hose may be used to conduct the liquid by gravity to the plants, the stream being controlled by hand pressure. Booms of iron piping stretching over the plants from a tank or barrel with rubber hose attachments have been used to good effect. No expensive or complicated equip-

ment is necessary or desirable, for corrosive sublimate as the name implies is corrosive, and iron, tin or other metal containers are readily affected.

A stock solution may be made by dissolving in a wooden container one pound of corrosive sublimate in eight gallons of boiling water. This may be done by suspending the salt in a muslin sack and pouring boiling water over it. The stock solution may be reduced by mixing one gallon of it with nineteen gallons of water. A field of 25,000 cabbage plants will require about three pounds of the corrosive sublimate; about four gallons of the diluted mixture being used for every 200 to 300 plants.



Root of Cabbage showing Cabbage Maggots and
their destructive work.
(After Gibson and Treherne.)

In order to facilitate the applications a great deal may be accomplished when hoeing or cultivating the fields. The soil may be "worked up" cup-shaped, around the stems of the plants, so that the water will readily remain around the plant.

THE ONION MAGGOT

There are two methods of Onion Maggot control which have given satisfaction in various parts of Canada, viz.: the Poisoned Bait method, and the Trap Crop method. In irrigated sections the "trap crop" method is mainly relied upon, while in those sections where the crop is grown under normal soil and moisture conditions the former method is in favour. It is not possible at this time to explain the reason for this, but it is thought to be due to the presence or absence of available water in the immediate neighbourhood of the onion plantations. The presence of water in open irrigation ditches, the subsoil seepage in the

vicinity of watercourses, and the rivulets of water between the rows appear to attract the flies and detract from the value of the baits. Frequent rains in a non-irrigated district may have a similar effect. When the soil surface is dry and friable, the presence of water, in which is dissolved a soluble arsenic, placed in cans, saucers or pie dishes, apparently acts as an attractant.



Bulb of Onion Plant destroyed by
the Onion Maggot.
(After Gibson and Treherne.)

The Poisoned Bait Method.

Experiments have demonstrated that approximately ten days elapse between the emergence of the adult flies and the commencement of their egg-laying. During this period, which is known as the preoviposition period, the flies are active, especially on bright, warm, sunny days, and are readily attracted to moisture. Advantage may be taken of this habit to establish a control measure. The following bait has been used with satisfactory results:—

Sodium arsenite..	$\frac{1}{4}$ to $\frac{1}{2}$ ounce
Cheap molasses..	1 pint
Water..	1 gallon

The sodium arsenite is first dissolved in boiling water and the molasses then added. From twenty to forty pans, pie dishes or china saucers are then arranged on the soil surface over each acre. The containers are filled with the poisoned liquid, first when the seedling onions are $1\frac{1}{2}$ to 3 inches high, and then on four or five later occasions as warranted. Some moss, straw, hay or excelsior, is

usually placed in the containers to serve as a resting place for the flies while feeding. An air-tight reservoir filled with water, inverted over a pie dish, on a similar plan to a chicken drinking fountain, may serve to retain the moisture content for a greater length of time, and thus obviate the necessity of continued refillings. A felt pad arranged in the tray around the reservoir will, in such a contrivance, serve as an absorption surface. An unused tomato-preserving can is suggested as a suitable reservoir.

Excellent results have also been obtained by sprinkling the poison bait mixture in the form of large drops over the soil and foliage of onions and neighbouring vegetation. It may be applied from an ordinary watering can with a small "rose" attached. Acre plots of onions may be treated quickly by the operator beginning at one end of the plot and walking diagonally across the field back and forward in a V-shaped course, the strips being about 15 or 20



Young bean plants destroyed by the Seed-corn Maggot.
(After Gibson and Treherne.)

feet apart at the wide end. The first application should be made in the spring at the same time as with the "pan" system, followed by four or five applications made about a week apart. Select bright, calm days, if possible, for such work.

The Trap Crop Method.

In the autumn of the year select and save a supply of undersized, misshapen cull onions from the season's crop. Set these onions four inches deep in the soil in rows, 100 feet apart throughout the plantation, at the time of seeding. These onions will produce a leaf growth four or five times greater than that of the seedling onions at the period when the flies are depositing their eggs, and this serves to attract the flies for oviposition. Pull up and destroy these trap onions about June 15 or at the time when the greatest number of first generation maggots are present. This date will need determining in each section where this method of control is being practised.

The Combination Bait and Trap Method.

In districts where doubt exists as to the method of control which should be followed a combination of the two methods may be employed. However, instead of setting the cull onions in long rows throughout the plantations they may be set in a ring or circle around the bait containers. This latter suggestion has been made by Mr. W. J. Tawse, of Macdonald College, P.Q.

THE SEED-CORN MAGGOT

THE SEED-POTATO MAGGOT

These two insects are not regularly occurring pests. This is fortunate as it is extremely difficult for the farmer or market gardener to anticipate their presence in his fields. The Seed-corn Maggot chiefly injures the seeds and young seedlings of such crops as corn, beans and peas; the Seed-Potato Maggot does injury to the developing tubers of potatoes, young seedling cucumbers and partly grown roots of turnips. If it were possible to anticipate the attack, or if it were deemed necessary to protect valuable crops, the corrosive sublimate treatment, recommended for the Cabbage Maggot, would doubtless prove effective in control although no positive evidence in this regard has been obtained.

Under ordinary conditions proper soil treatment by cultivation and the planting of seeds with a high vitality is all that is necessary to safeguard crops against these insects. When seed is planted during a period of cold, damp weather, decay is liable to set in. Such conditions possibly render the plants more attractive to the adult flies for egg deposition.

GENERAL MEASURES FOR CONTROLLING ROOT MAGGOTS

As Root Maggots are usually present throughout the growing season it is advisable to destroy all remnants of crops, such as the stumps of cabbage and cauliflowers. Inasmuch as the flies are able to travel in flight at least a quarter of a mile, changing the location of fields each year is desirable. Crop rotation should be practised and care should be taken in selecting crops that are not liable to infestation. There is an objection to the free use of barnyard manure, inasmuch as the flies appear to be especially attracted to heavily manured fields. Where maggot attacks may annually be expected the use of commercial fertilizers is probably preferable. In locations where crops are being grown for cattle feed, such as field turnips in a dairy district, where the expense of applying corrosive sublimate is considered unwarranted and insecticide applications are impractical, heavy seeding (about fifty seeds to the lineal foot) is advised. Selective thinning in June would probably obviate the necessity of further control measures.